A supplementary to article titled "*Ionospheric Perturbations due to large thunderstorms and the resulting Mechanical and Acoustic Signatures*"

In this supplementary material, we present additional results to support the results and findings in the paper titled mechanical and acoustic signatures of the ionosphere during thunderstorm. The plots shown in Figure S1 to Figure S12 shows the TEC deviation for months without thunderstorm in the year 2013 and 2016 from which some of the thunderstorm cases were selected.

S1. Days of the Year Without Storm

The figures below represent the days in the months of the of the year without thunderstorms (see Figures S1 to S6). In Beijing January is typically one of the months without thunderstorm.

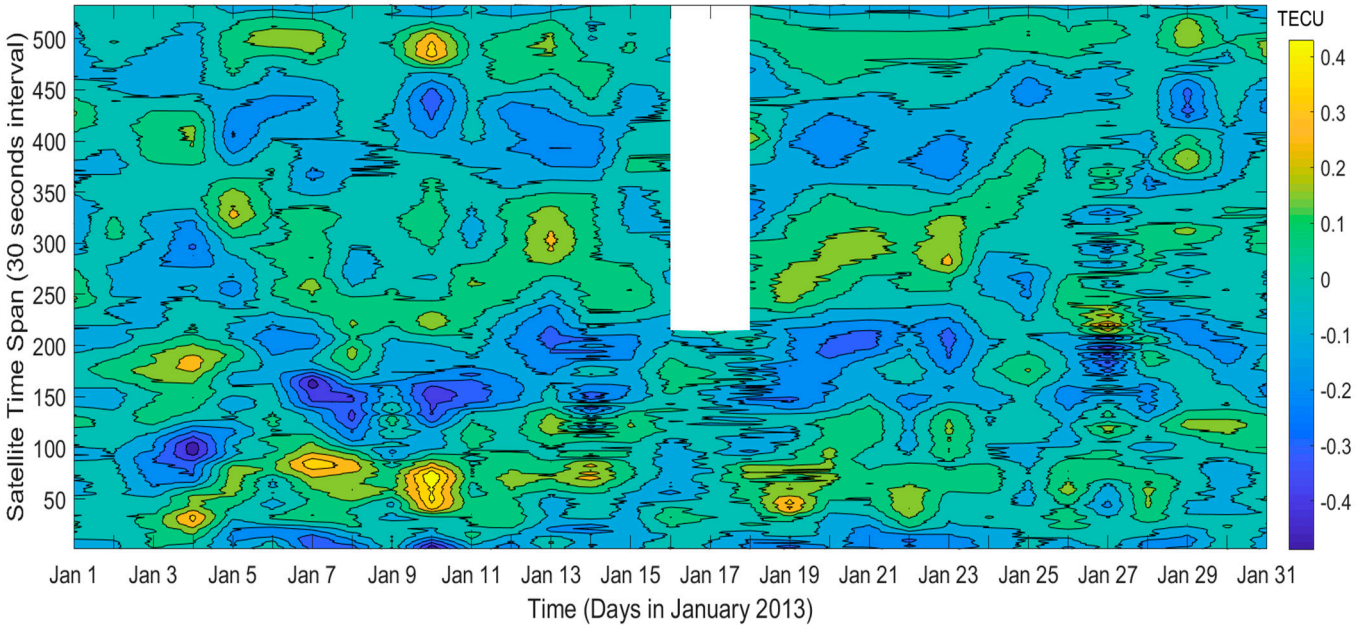

Figure S1. Spatial time plots of TEC deviations measured by PRN 14 in January 2013 representing days without thunderstorm.

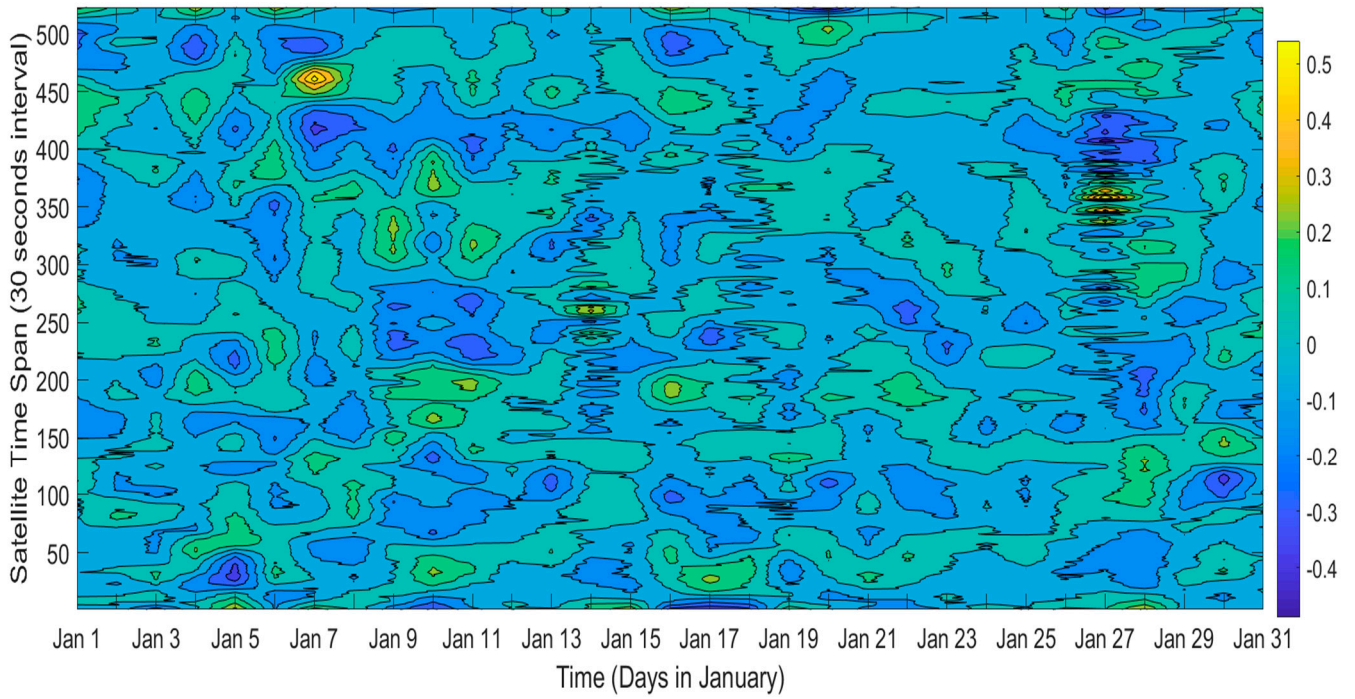

Figure S2. Spatial time plots of TEC deviations measured by PRN 18 in January 2013 representing days without thunderstorm.

The TEC deviations for January 2013 show a regular low scale TEC irregularity, that mostly represent the variations in the background dynamics of the ionosphere. Some regions in the plot with high TEC deviations and low TEC depletions are mostly characterized by other activity.

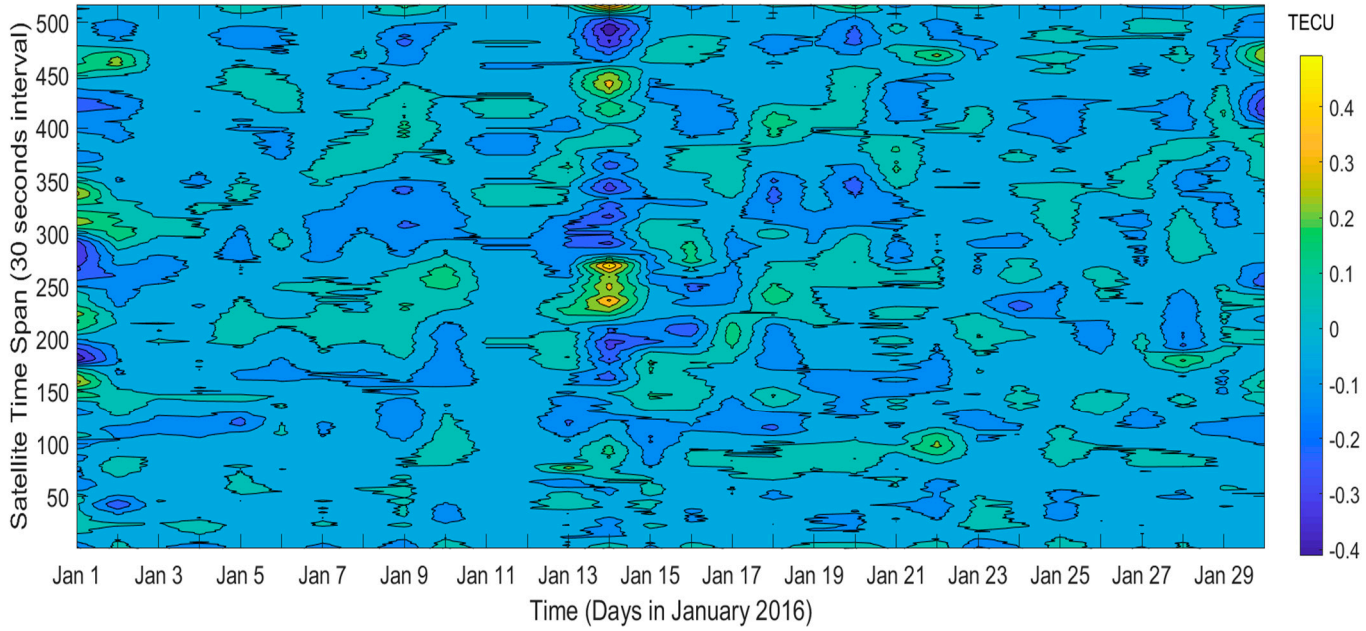

Figure S3. Spatial time plots of TEC deviations measured by PRN 11 in January 2016 representing days without thunderstorm.

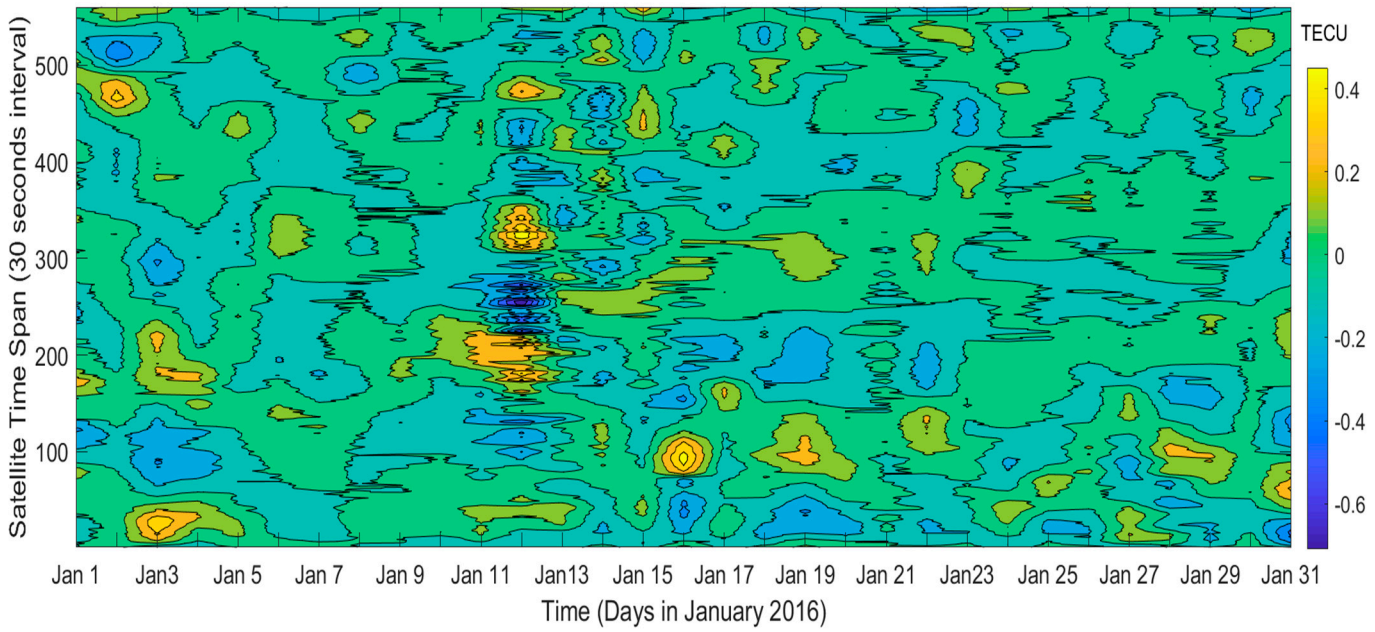

Figure S4. Spatial time plots of TEC deviations measured by PRN 26 in January 2016 representing day without thunderstorm.

Similar to January 2013, the TEC deviations for January 2016 show a regular low scale TEC irregularity, that mostly represents the variations in the background dynamics of the ionosphere. Some of the time periods within the plot reveal a high TEC deviations and low TEC depletions, which are mostly be attributed to solar activities. In the absence of solar activities, the values of TEC deviation were found to be lower than ± 0.4 TECUs and in most cases the TEC deviations are lower than the ± 0.25 TECUs. In the presence of solar activities, the TEC deviations were found to be higher than ± 0.5 TECUs and even as high as the ± 0.6 TECUs in most cases. In all these highlighted situations, we have found the TEC deviations to be much higher in the thunderstorm cases considered with thunderstorm induced TEC deviations as high as High as the ± 2.0 TECUs (please refer to the main article). To avoid the conflict of interpretation and for clarity of inquisition, we have separated the influence of solar activities from all the analysis presented in the main article.

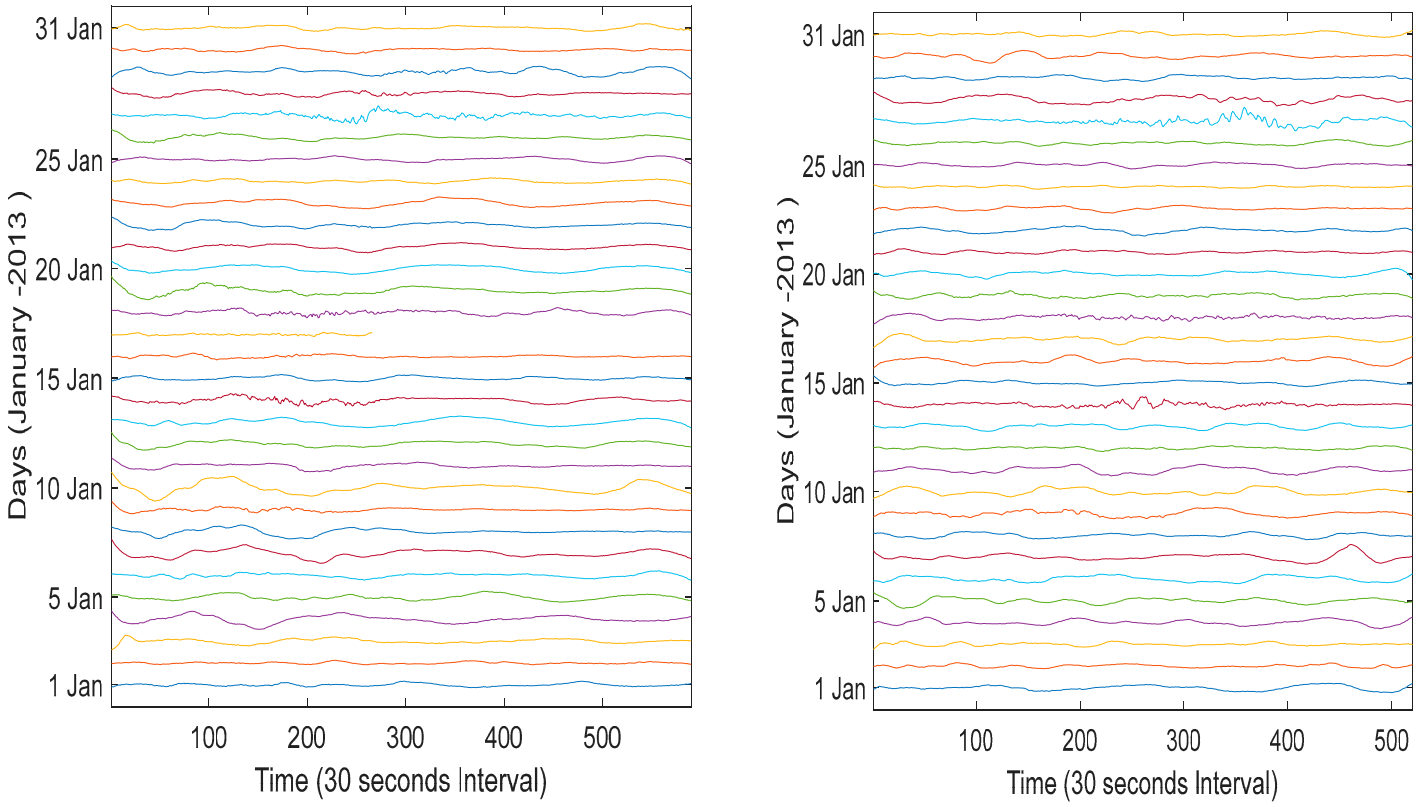

Figure S5. Line plots for the variations ionosphere for days in January 2013 observed from PRN 14 (left panel) and PRN 18 (right panel).

The line plots show mostly non-wavelike signatures which are mostly like saw-tooth waveforms besides the signatures, the magnitudes of ionospheric disturbance depicted by the TEC deviations are significantly low compared to the TEC deviations measured during thunderstorm events.

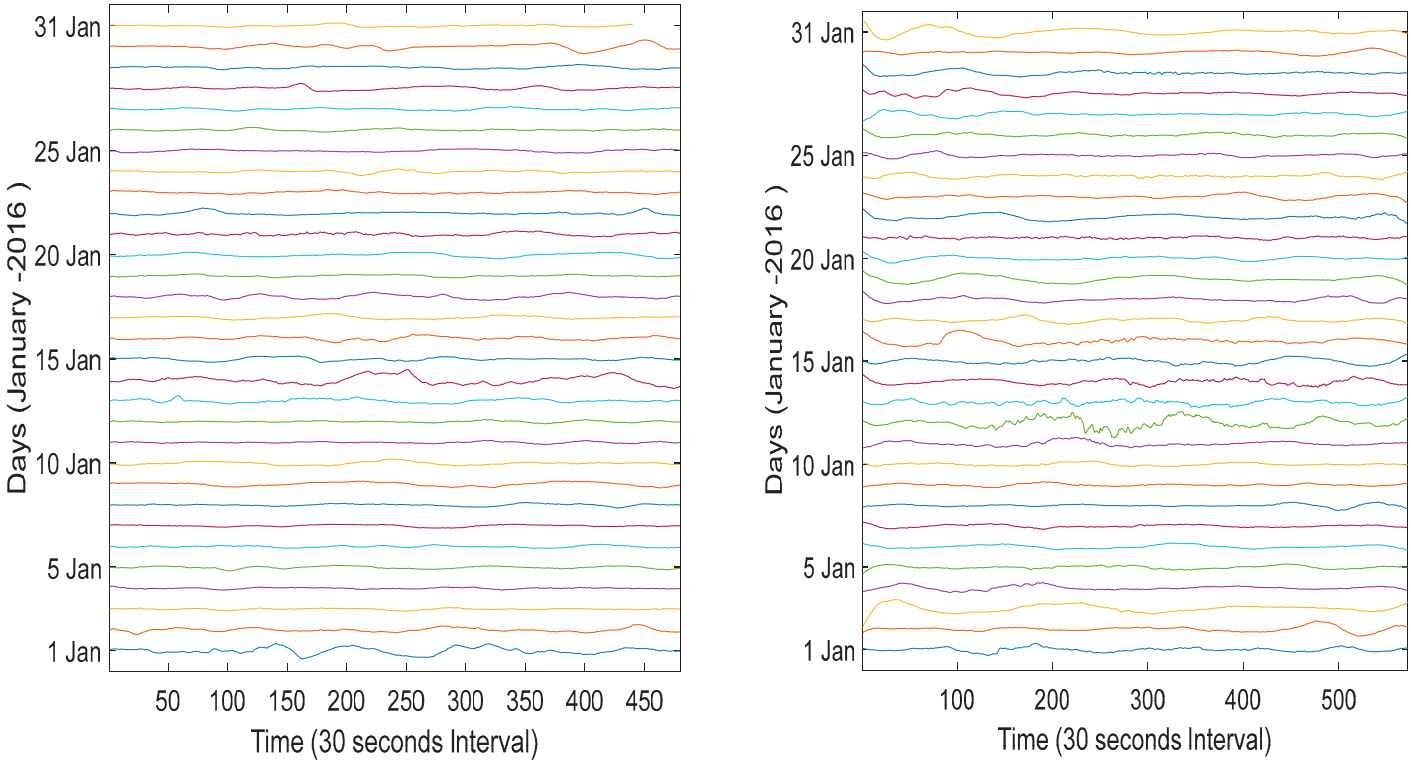

Figure S6. Line plots for the variations ionosphere for days in January 2016 observed from PRN 11 (left panel) and PRN 26 (right panel).

S2. TEC deviations for days around the Thunderstorm

The days surrounding the selected major thunderstorm days were characterized by lightning flashes as these days are days in the months of June, July, and August for the year 2016 and 2013. This month are situated in the monsoon periods in the selected region of China, and they are characterized by frequent thunderstorm and the atmosphere are sometimes characterized by cloud overcast. As a result of the weather conditions in this region, days without thunderstorm are sometimes difficult to find. However, the TEC variations for the days around thunderstorm were computed comparison between the days (See Figure S7 for the TEC deviation and Figure S8 for the corresponding stroke count). It was observed that the days with less lightning strokes had lower TEC deviations. And the day with higher lightning flashes has the highest TEC deviation, as seen in Figure S7 for the 21st of June 2016 and Figure S9 for July 31, 2013, with corresponding stroke count in Figure S10. Even though the highest TEC deviations mostly coincide with the highest flash rates, the presence of the day-to-day thunderstorms is also responsible for the relatively high TEC deviation signatures observed for the days around the thunderstorm.

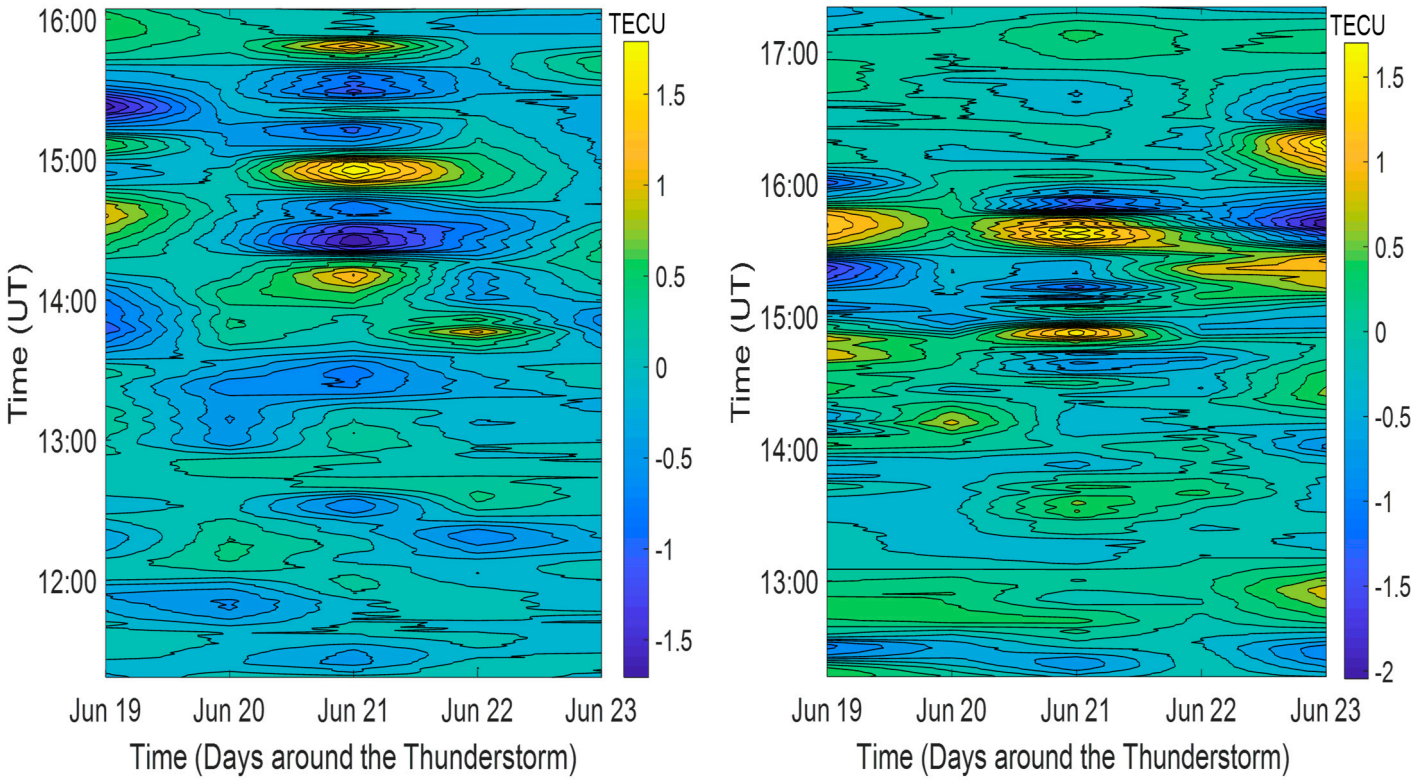

Figure S7. TEC deviations for the days around the thunderstorm on 21st of June 2016 observed by PRN 2 (left panel) and by PRN 5 (right panel)

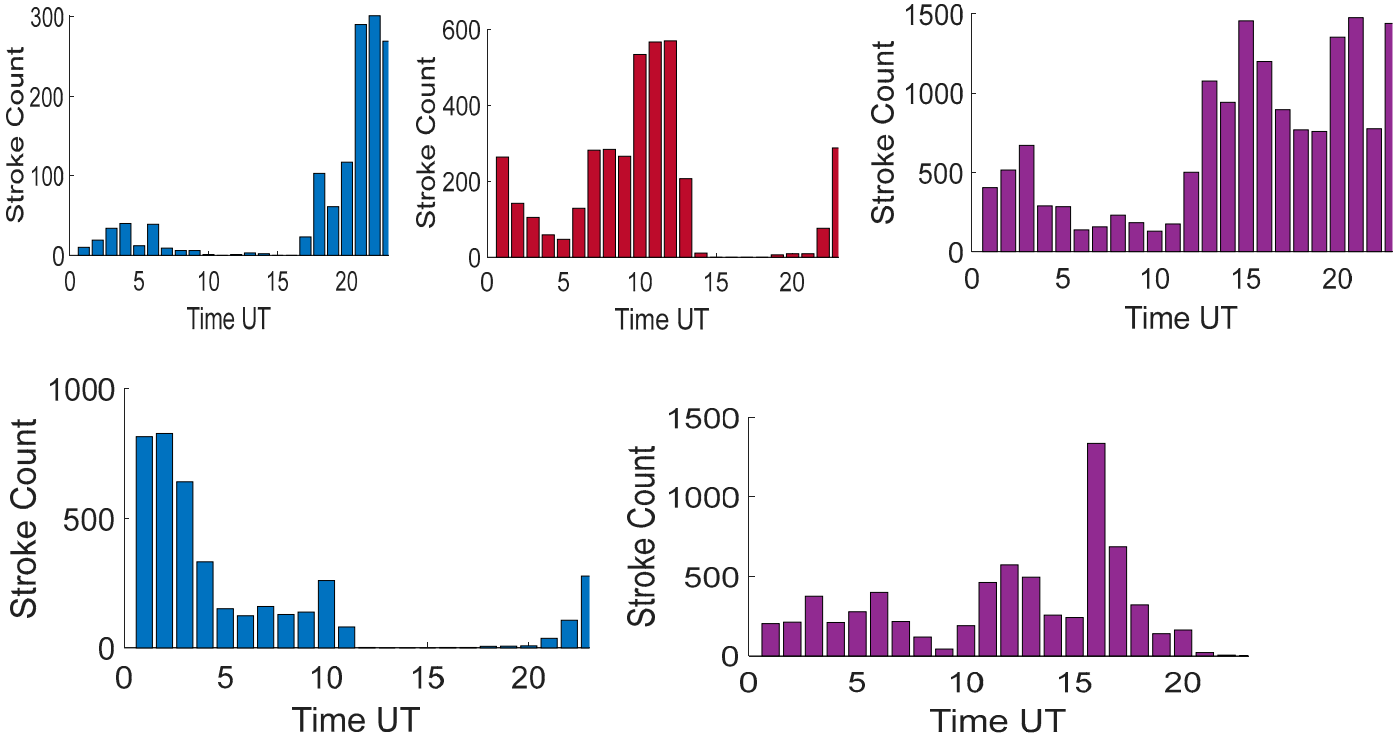

Figure S8. The stroke Counts for 19th of June to 21st of June 2016 (**Upper panels**: Left to right) and 22nd to 23rd of June 2016 (**Lower panels**: Left to right) show the varied periods without lightning flashes and the periods with intense lightning.

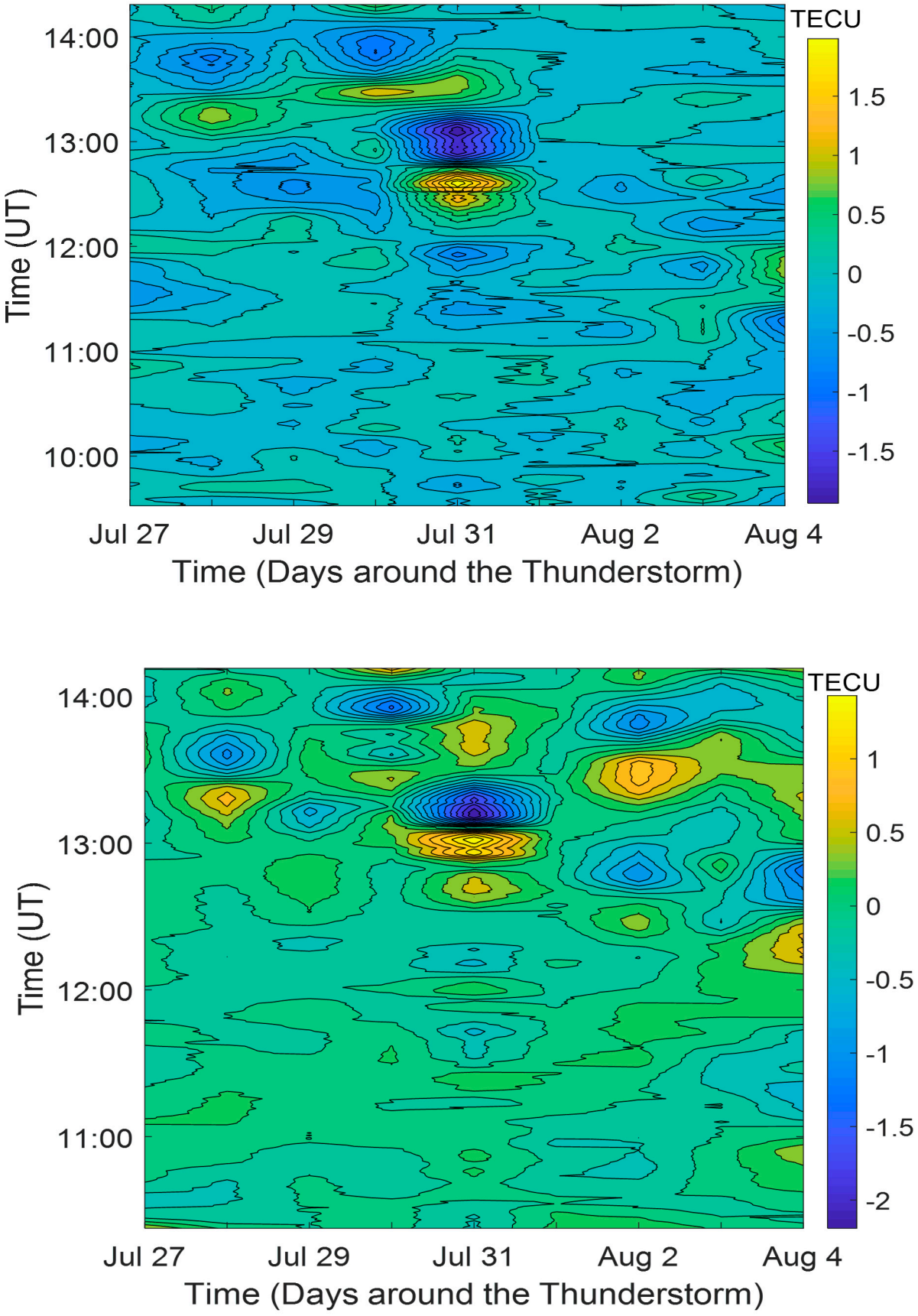

Figure S9. TEC deviations for the days around the thunderstorm on 31st of July 2013 observed by PRN 4 (upper panel) and by PRN 5 (bottom panel)

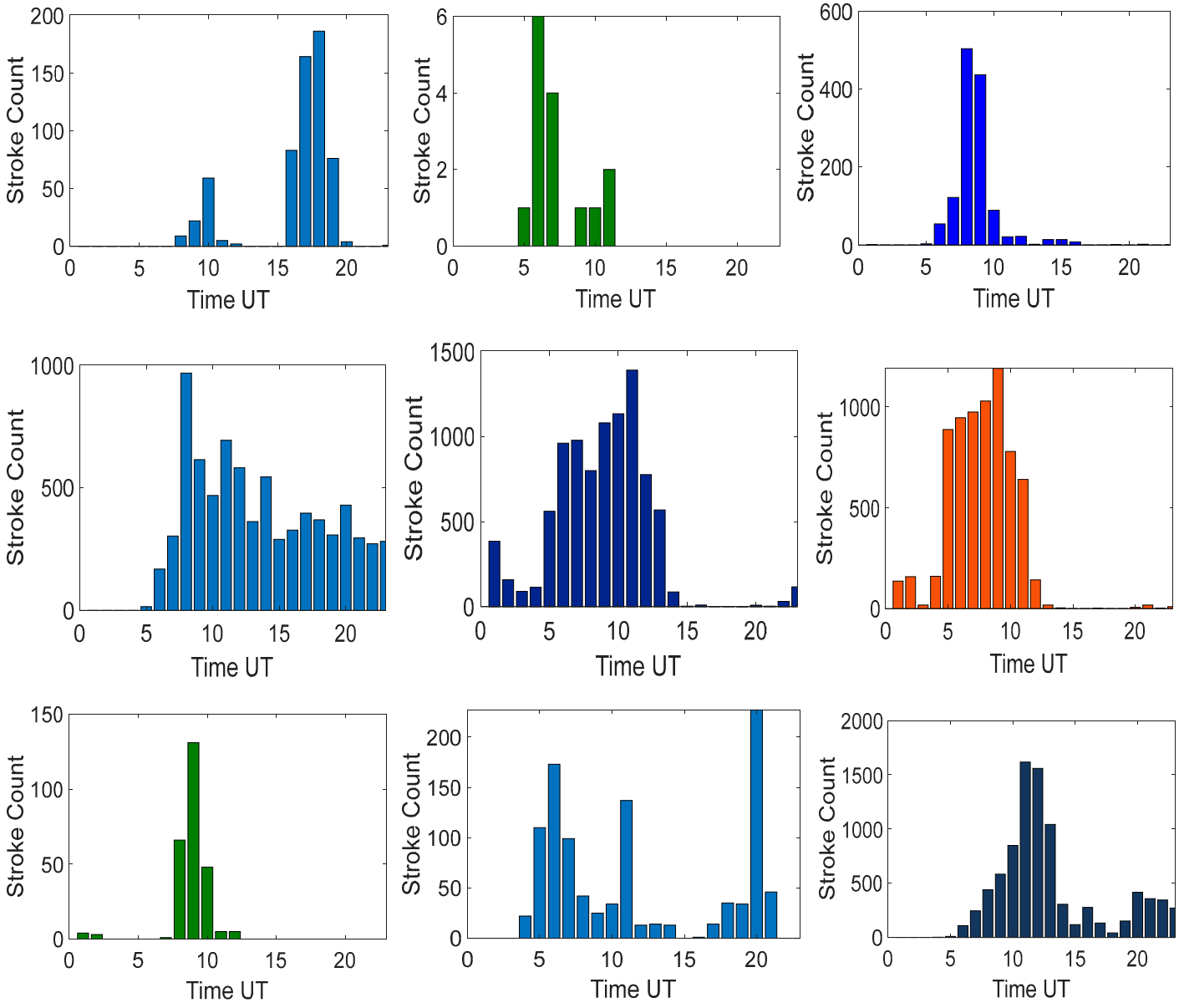

Figure S10. The stroke counts for 27th of July to July 29 (**Upper panels**: Left to right), July 30th to 1st of August (**Middle panels**: Left to right) and 3rd to 4th of August (**Lower panels**: Left to right) 2013 show the varied periods without lightning flashes and the periods without the lightning.

S3 Spatial-Time TEC deviations and Spatial TEC deviations

Presented below are space-time plots of TEC deviation and the spatial TEC deviation to further illustrate the variation of the spatial TEC deviations with respect to time (see Figure S11). Figure S12 shows and additional spatial plot for TEC extrapolated absolute peak TEC near the location of the highest storm at Shanghai.

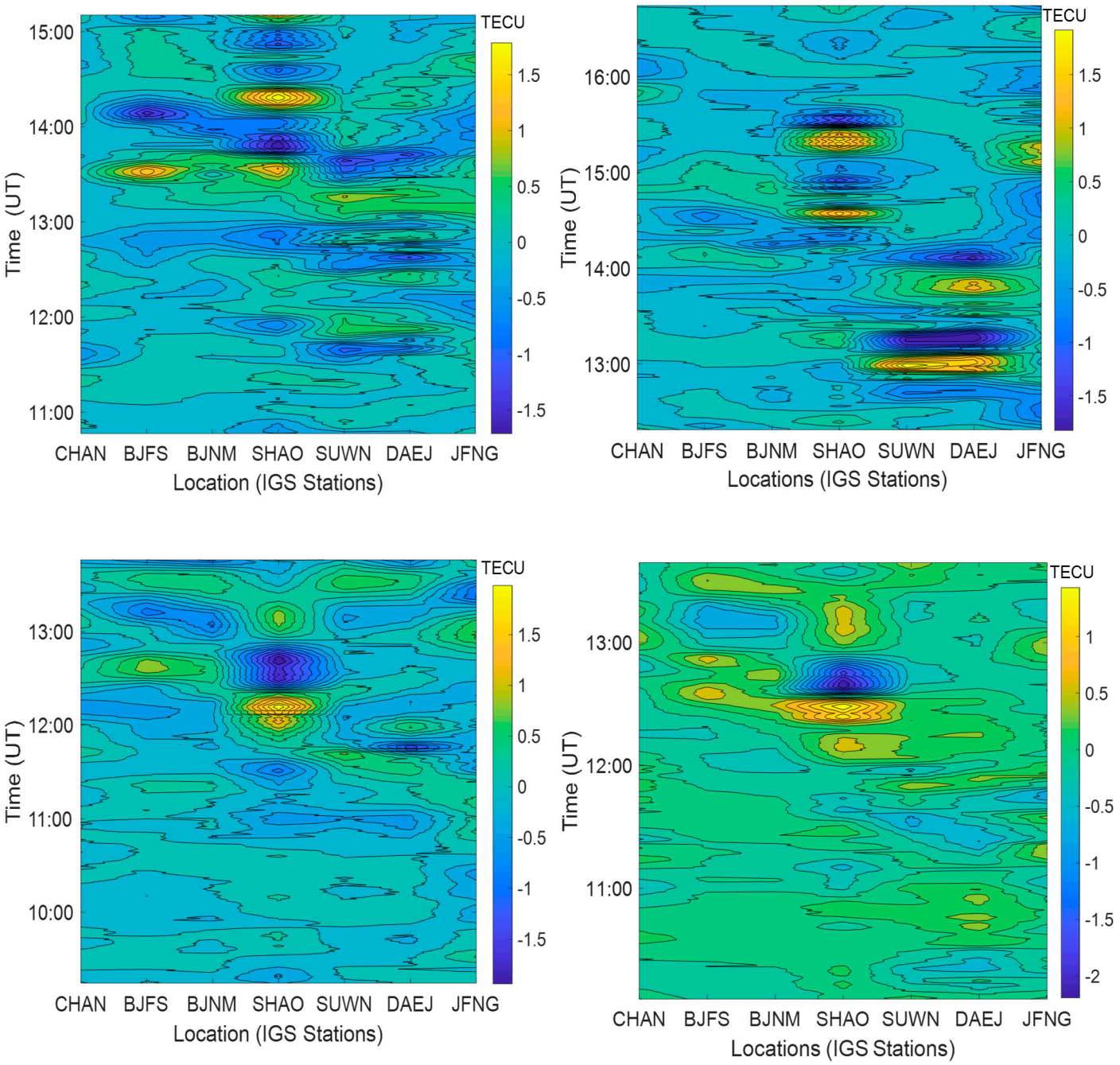

Figure S11. Spatial time illustration of TEC deviation **Upper Panels**: The observed TEC deviations for the thunderstorm event of 21st of June 2016 obtained from PRN 2 (upper left) and from PRN 5 (upper right). **Lower Panels**: The observed TEC deviations for the thunderstorm event of 31st of July 2013 obtained from PRN 4 (upper left) and from PRN 10 (upper right).

The spatial time TEC deviation is another approach for illustration of the dynamical variations during thunderstorm given above for two of the major thunderstorm events studied in this work, which are the events that took place on 21st of June 2016 and on 31st of July 2013. This illustration of spatial-time TEC deviation is another form of demonstration representing the variations shown in the uniformed line plots (Figures 3c and

4c) in the main manuscript. This illustration shows the actual magnitude of TEC deviations for the stations each of the stations of the period of the GPS satellite visibility.

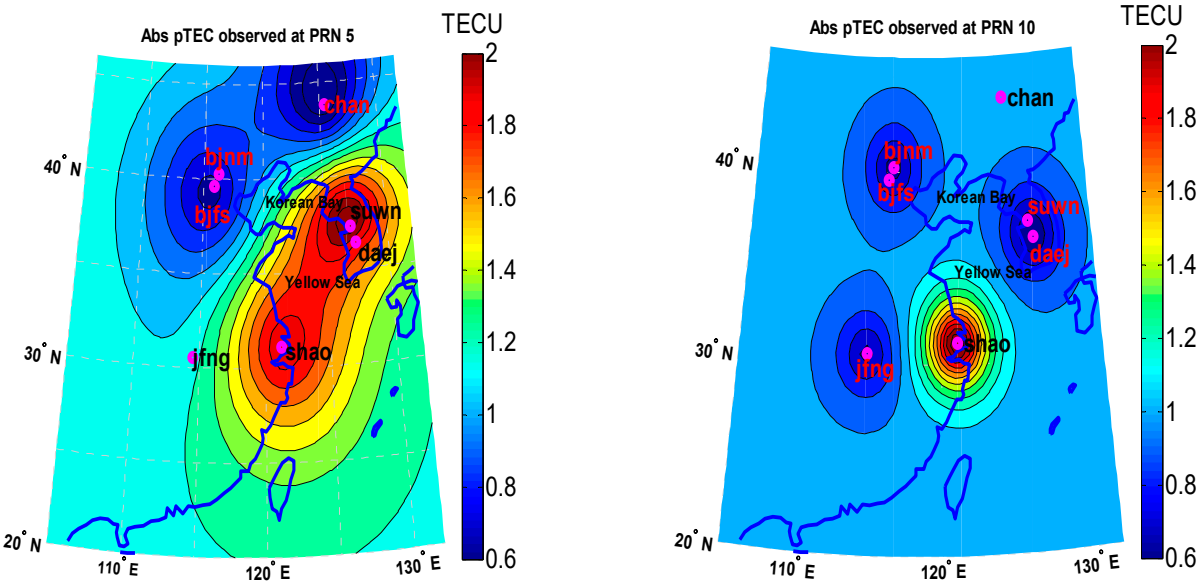

Figure S12. Contour of extrapolated absolute peak TEC showing highest TEC near the location of the highest storm at Shanghai as observed from PRN 5 on the 21st of June 2016 (left panel) and the observation from PRN 10 on the 31st of July 2013.